EXTENDED ARRAY EVALUATION PROGRAM

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13 ABSTRACT

This sixth quarterly report summarizes progress made under the Extended Evaluation of ALPA, NORSAR, and VLPE program Contract Number F33657-72-C-0725. Work to date in the following areas is summarized:

- NORSAR long period evaluation
- NORSAR short period evaluation
- VLPE evaluation
- Research
- Seismic system study

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SECTION I

INTRODUCTION AND SUMMARY OF EVALUATION TASKS

This sixth quarterly report summarizes progress made during the last quarter, 1 July 1973 to 30 September 1973, on the Extended Evaluation of the ALPA, NORSAR, and VLPE Program being conducted by Texas Instruments Incorporated at the Seismic Data Analysis Center in Alexandria, Virginia. The program consists of the following five tasks:

- Continued evaluation of the long-period Norwegian Seismic Array (NORSAR)
- Continued evaluation of the short-period NORSAR
- Continued evaluation of the stations of the Very Long Period Experiment (VLPE)
- Evaluation of two advanced processing techniques: the Lamont three-component adaptive filter and the similarity detection algorithm (F-detector)
- Investigations of network processing and analysis techniques for the seismic network system study.

The software required to perform these evaluations was developed under contract F33657-69-C-1063.

At the end of this quarter, the NORSAR, VLPE, and research tasks were successfully completed. The remaining task, the seismic network system study, is continuing into the next quarter.

Special Report No. 6, concerning the VLPE station and network evaluation, Special Report No. 8, concerning the final ALPA evaluation; and Special Report No. 10, concerning the ambient noise at the VLPE stations, were approved and have been distributed. Special Report No. 9, concerning the short-period NORSAR evaluation, was submitted for approval.

At the conclusion of the long-period NORSAR evaluation this quarter, 50 additional events had been processed producing a total data base of 517 events, including 24 presumed explosions. Measurements of signal beamforming loss and noise reduction have been made on approximately 24 signals with noise using beamsteer and multichannel filters for both the full array and a subarray of the inner ring elements. Noise analysis continued with twelve new samples from 1973 data being added. This evaluation will be reported in Special Report No. 12 now in preparation.

Processing was completed for the NORSAR short period evaluation in this quarter. The total data base consists of 567 events, of which 33 are presumed explosions from Eurasia. Preparation of the report discussing the overall results of the short-period NORSAR evaluation, Special Report No. 11, was essentially completed by the end of the quarter. This report will include maximum-likelihood estimation of NORSAR short-period detection thresholds and evaluation of short-period discriminants.

The combined performance of NORSAR short- and long-period discriminants will be evaluated in Special Report No. 13. Work on this report was undertaken in this quarter, but was not completed by the end of the period.

An evaluation of the noise characteristics of eight VLPE stations, the detection and discrimination capabilities of eleven VLPE stations, and the VLPE network was completed this quarter. Spatial and temporal noise relationships at the eight VLPE stations were determined using data previously reported by Alsup and Becker (Special Report No. 10) plus an additional 379

vertical and 133 horizontal one-hour noise samples from November and December 1972, and January 1973 data.

An additional 1447 station-event combinations from events in August, November, and December 1972, have produced a total data base of 3577 station-event pairs and have allowed refined estimates of detection and discrimination to be made. Chirp and reference waveform matched filters and the Lamont processor have been evaluated at all VLPE sites using a set of events from the Kazakh-Kirgiz-Sinkiang region. Special Report No. 14 which discusses these results is now being prepared.

During the last quarter, the evaluation of the Lamont processor and a comparison of the Fisher detector and conventional power detector were completed. The signal-to-noise ratio gain of the Lamont processor was measured over a wide range of signal-to-noise ratios using both beamed and single site data. The detection and false alarm probabilities were measured using VLPE station data and synthetic random noise. A final report on the Lamont processor evaluation is in preparation. The false alarm rate and the detection probabilities of the Fisher detector and a conventional power detector were measured, as a function of detection level, using long noise samples and a large number of low magnitude events. From this data, curves of detection probability versus false alarm rate have been defined for various detector parameters. A final report on this study is also in preparation.

SECTION II
SEISMIC NETWORK SYSTEMS STUDY

The functions of a seismic monitoring system have been described by specifying the operations to be performed by that system. A brief description of these functions is as follows:

(1) Standard Array Configuring -

Determine the number and distribution of short-period (SP) and long-period (LP) sensors in order to minimize main lobe width and side-lobe response with nearly uncorrelated noise on each sensor.

(2) Sensor Data Collection -

An independent cable or radio linkage between sensors and a local data collection point designed to detect and correct failures in sensors or linkage and provide reliable and efficient digital data representation.

(3) Station Detection Processing (SDP) -

Detect, estimate, and store signal power and propagation parameters every 0.5 seconds and maintain a six hour running file for use in detection or verification of possible events. Store SP and LP data for at least six hours for possible delivery of waveforms to the central facility. Implement a threshold strategy to generate a bulletin used to facilitate the preliminary location and association of event waveforms at the central facility. For a centralized system SDP functions are performed at the central facility.

(4) Station Communications Processing -

Prepare data and engineering information for transmission to the central facility with error detection capability suitable for bulletin or data transmission. Design parameters include record header definition, frame header definition, digital representation of data words and block error coding.

(5) Communications -

Sizing low-rate and high-rate communications requirements for station bulletin transmission, station status information, station waveform transmission, and data or information requests from the central facility. Determine availability and cost of alternatives such as direct INTELSAT links to remote stations or relayed data collection by four regional ground stations linked to INTELSAT.

(6) Communications Processing (COM) -

A centralized processing system to receive all sensor data, deliver the data to the appropriate station processor module in the central facility, and confirm and report status of communications and equipment at all remote stations. For decentralized processing, the COM would receive detection bulletins, data, and status information from remote stations, send requests for data and information, and monitor requests, deliveries and queuing status.

(7) Network Detection Processing (NDP) -

For a centralized processing system only this system would perform SDP functions at the central facility.

(8) Detection Association Processing (DAP) -

This function would be to receive key event detections and make a preliminary location from at least one array. It would also verify the location at other arrays and single stations and use this information to make a

preliminary location. Based on this location waveform delivery requests are sent to stations within detection range. Beamed waveform estimates are sent to the central facility.

(9) Event Classification Processing (ECP) -

This function is to receive waveforms from all stations, perform phase classification, location, explosion/earthquake parameter definition, discrimination processing, and preparation of data for the data bank. Special data base files are prepared for events of doubtful or possible explosion classification. Event bulletin definition and formatting, regional statistics file definition, ARPANET (users) and data bank interfacing, statistics updating capability and parameter or program updating capability are principal design tasks.

(10) Central Facility Executive Processing (CEP) -

The executive processor receives information on user traffic, request queuing, and equipment and communication status for the entire system for the purpose of updating the system status, controlling mean-time-to-repair, and maximizing usage of the data base.

Besides detailed definition of the above functions, the systems study is considering tradeoffs in the implementation of the functions. Some of these are communications versus no communications, high rate versus low rate communications, arrays or subarrays versus single sensors, independent functional mini-computer modules versus large general purpose computers, centralized data processing versus data processing at remote stations and automatic versus interactive network processing.

The topics to be considered this quarter are interactive processing capability, communication system capacity and cost, and central facility processing requirements. These requirements include communications

control, detection association, event classification, and central facility executive processing. Algorithms for associating single station detections will be considered from the point of view of threshold optimization, cost-effectiveness, and operating characteristics.